GIS Analysis of Firearm Morbidity and Mortality in Atlanta, Georgia

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Due to the sensitive nature of the datasets and their use in ongoing police investigation and enforcement activities, maps cannot be included at this time.

Abstract

Collaboration with public health researchers and use of geographic information system (GIS) analysis can help law enforcement agencies identify the times and places where most firearm homicides and aggravated assaults occur. To guide and evaluate the efforts of a local multi-agency task force developed to reduce firearm crime in the city of Atlanta, Georgia, the authors analyzed key local datasets to identify "hot spots" of firearm-related crime. While overall homicide rates declined over the past 10 years in Fulton County, Georgia (which includes most of the city of Atlanta), homicide rates for 15- to 19- and 20- to 24-year-olds increased. All of the increase in these age groups was due to a sharp increase in firearm homicides. Non-firearm homicides have remained stable. GIS analysis of county medical examiner firearm homicide records (1989–1997), City of Atlanta 911 system firearm-related calls (shots fired, person armed, person shot calls for 1997), and reports of aggravated assaults with a firearm (non-fatal shootings) indicated hot spots of firearm-related morbidity and mortality in specific police zones, beats, and census tracts within the city. Within beats and neighborhoods, high-frequency streets, intersections, public housing units, and time periods were identified. Analysis of data according to census tract indicated a higher frequency of events in tracts that were above the state, county, and citywide mean for socioeconomic status indicators such as female-headed household, percent male unemployment, and percent below poverty level. GIS data and trend analyses are reported regularly to the multi-agency task force, where they are used to assist in case investigations and target enforcement operations.

Keywords: firearms, homicide, assault, injury, prevention

Literature Review and Statement of Problem

Homicide is the second leading cause of death for Americans between 15 and 24 years old, and it is the leading cause of death among African-American youth. Among persons 25 to 44 years old, it is the sixth leading cause of death (1). Firearm homicide accounts for an increasing percentage of overall homicide in national figures. In recent years, national statistics have shown a decline in overall homicide. Among juveniles and young adults, however, we have seen a dramatic upsurge since 1985. When broken out by age group, firearm homicide accounts for nearly all homicides among 15- to

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19-year-olds. Recent research indicates that although national rates of firearm homicide among juveniles and young adults have declined slightly since a peak in 1993, they still remain high. Non-firearm homicide has remained stable over time.

Public health and law enforcement agencies have an interest in reducing the incidence of firearm homicide and assault, mortality, and morbidity. Two strategies in criminology and law enforcement—problem-solving policing and community-oriented policing—follow tactics similar to public health research and practice. Geographic information systems (GIS) analysis can help target the problem, identify intervention points likely to have the greatest effect, guide implementation of a strategy, and evaluate its impact.

In a publication for the National Institute of Justice, Rich (2) outlines two goals for the use of GIS in the analysis of crime and victimization. The first is to further an understanding of the nature and extent of criminal and social problems in a community. The second goal is to improve the allocation of resources to combat these problems. Once "hot spots" of crime events have been identified, GIS can be used to determine if an intervention or prevention strategy suppressed new events or displaced criminal activity to other locations.

The utility of GIS to identify high-frequency areas of crime events and target law enforcement efforts has been established. Taylor and Gottfredson (3) concluded in 1986 that neighborhoods show different levels of crime across geographic boundaries, and "that there is evidence linking spatial variation in crime to the physical and social environment at the sub-neighborhood level of street blocks and multiple dwellings." Starting with the premise that crime is concentrated in specific areas that are not evenly distributed and that it is more efficient for police to concentrate their efforts on high crime areas, Sherman and Weisburd (4) conducted a one-year randomized trial in Minneapolis of an increased police presence in identified hot spots of crime. They reported that "observed disorder was only half as prevalent in experimental as in control hot spots. We conclude that a substantial increase in police patrol presence indeed causes reductions in crime and more impressive reductions in disorder within high crime locations" (4).

Weisburd and Green (5) analyzed narcotics sales arrests, drug-related emergency calls for service, and narcotics tip line information over a six-month period in Jersey City, New Jersey, to determine hot spot areas of drug activity. Using GIS, they determined that 14% of the city's intersections were the sites of most, if not all, of the drug activity in Jersey City (5). Working with the Jersey City Police Department, which had previously relied on "a series of loosely connected and unsystematic drug enforcement tactics," they designed an experimental strategy to reduce drug and drug-related activity. These investigators reported "consistent and strong effects of the experimental strategy on disorder-related emergency calls for service." They found little evidence of displacement to other areas, and in fact, reported a "diffusion of benefits" to surrounding areas (5).

History of the Project

In 1994, five counties in metropolitan Atlanta joined Project PACT (Pulling America's Communities Together), an ongoing federal violence prevention initiative intended to encourage local governments and federal agencies to work together to identify local

problems and create local solutions. Through Metro Atlanta Project PACT, area leadership and community stakeholders were asked to identify the most pressing violence problems in the project area. The participants identified youth firearm violence as a significant local problem and a top priority for the city. Although the original scope of the project covered five counties (Fulton, DeKalb, Cobb, Clayton, and Gwinnett), efforts were subsequently focused on Fulton County and the city of Atlanta.

Project Objectives

Shortly after Metro Atlanta Project PACT was initiated, a consortium of federal agencies announced their intention to fund evaluations of community-based approaches to reduce firearm violence among juveniles. The Emory Center for Injury Control (ECIC) received funding to provide a baseline assessment of the problem in the project area, provide ongoing process evaluation to help guide and refine the effort, and provide a summary evaluation to determine the effectiveness of Metro Atlanta Project PACT's efforts to reduce juvenile firearm violence in metropolitan Atlanta. The project was funded by the National Institute of Justice, the Office of Juvenile Justice and Delinquency Prevention, and the Centers for Disease Control and Prevention.

The project has three key objectives:

1. With partners, apply a problem-solving approach to developing, implementing, evaluating, and refining a comprehensive youth firearm violence prevention strategy.
2. Determine whether broad-based community action can reduce juvenile firearm violence.
3. Evaluate the utility of retrospective and prospectively collected local data to guide the development and refinement of violence prevention countermeasures.

The firearm mortality, morbidity and emergency call data presented here were collected and analyzed in support of this project.

Methods

The project area, Fulton County, lies in the northwest quadrant of the state of Georgia, claiming 338,364 acres of land. Population density has increased steadily in the past decade; in 1990 there were 1.98 persons per acre, and in 1997, there were 2.25 persons per acre. One of 159 counties in Georgia, Fulton is the most populous, with 760,100 residents in 1997. The county is roughly 50% white and 50% African-American. The population of the county more than doubled between the 1980 and 1990 censuses (6). In 1995, Fulton County was ranked first in the state for per capita personal income, well above the state and national average. Much of the wealth, however, is concentrated in the northern third of the county and the northern half of the city of Atlanta. The southern half of the city and the central and southern thirds of the county have large concentrations of working poor and unemployed citizens.

Atlanta, contained primarily in Fulton County, is home to 426,300 residents—56% of the county population in just under 25% of the total land area. Atlanta's resident population is approximately 67% African-American, which is 77% of the county's total African-American population. The downtown area is home to major business, industry,

and finance concerns, as well as host to a large convention and tourism industry. There is significant commuter traffic into the city during business hours. In the city of Atlanta, the Atlanta Police Department's (APD's) jurisdiction is divided into six zones and 56 beats.

Indicators, Datasets/Data Sources, Collection Strategy

To characterize the nature of firearm mortality and morbidity in the project area, and to determine whether or not firearm-related events cluster in identifiable high-frequency, or hot spot, places and times, the authors analyzed four key datasets.

Overall homicide and firearm homicide rates for Fulton County were obtained from the National Center for Health Statistics for 1968 to 1995. Yearly rates were broken down by gender and race.

Death records for all firearm-related deaths 1989 to 1997 were obtained from the Fulton County Medical Examiner (FCME). The FCME investigates and records all deaths occurring within the boundaries of the county. The inclusion criterion for this dataset was all individuals who died in an incident involving a firearm in Fulton County, either on the scene or from injuries resulting from a shooting. Dates of inclusion are 1/1/89 through 12/31/97. All data on race, age, sex, and resident/non-resident status were included. Each case record includes medical examiner case number, name, age, race, sex, date of birth, home address, report date and time, incident date and time, and location of incident. The data were obtained as a dBase IV file download from the FCME.

Emergency 911 computer-aided dispatch data (CAD) for a subset of firearm-related call types were obtained from Atlanta's E-911 system. This system covers only the city of Atlanta; it does not cover the remainder of Fulton County. The Atlanta 911 dataset included all calls for call types 25 (shots fired); 50, 504, 5025 (person shot); and 69 (person armed) for the time period 1/1/97 through 12/31/97. Each record includes a unique identifier number, call type, incident location, the time and date of the call, priority, zone, beat, dispatch time, arrival time, call completion time, a brief description of the event, and related police numbers. The file was received as an ASCII download from the 911 Center and translated to a dBase IV file for analysis.

Finally, data on non-fatal firearm injuries were exported from a firearm injury surveillance system developed and maintained by the authors. The surveillance system tracks shooting incidents in the five-county area of metropolitan Atlanta (Fulton, DeKalb, Cobb, Clayton, and Gwinnett counties) and links police reports of shooting incidents, emergency department records, and medical examiner records to produce a complete picture of each firearm-related injury and death in the project area.

Data Analysis

The data were imported into Paradox 7.0 for Windows for table restructuring; the designation of variables as a character or numeric was necessary for ArcView 3.0a (ESRI, Redlands, CA) analysis. The data were also imported into Microsoft Excel 97 for separation of the incident location field and cleaning to assure a high rate of successful geocoding.

Descriptive Epidemiology

The data were imported into SPSS 8.0 (SPSS, Inc., Chicago, IL) for descriptive

epidemiological analysis. Frequencies were calculated for age, race, sex of victim, and the type of incident (homicide, suicide, accident, other). Cross tabs were calculated for race and sex of victim, and histograms of the time of incident were calculated. Results were displayed graphically using Microsoft Excel 97.

Geographic and Temporal Analysis

The data were imported into ArcView 3.0a and ArcView Spatial Analyst Extension for geographic analysis. Data were geocoded based on the street address or intersection of the incident location. Geocoding match rates varied by dataset, due to the quality of the address information. City of Atlanta 911 CAD data had a geocoding match rate of 89%. The FCME data had a match rate of 92%, and the firearm injury surveillance dataset had a match rate of 64%. The geocoding match rate for this dataset is much lower due to poor address data on the police reports.

Three types of maps were produced: point maps of incident location, broken down by age, sex, crash type, and time of day; areal maps, in which data were aggregated to police zone, beat, and census tracts using a spatial join; and isoarithmic maps, obtained using the calculated density function in ArcView Spatial Analyst Extension. Density calculations were created to determine the historical center of mass of firearm homicide and assault.

These data were collected and analyzed for immediate police utility and application by a multi-agency task force that was interested in the number of incidents in particular areas. Therefore, this paper discusses frequencies only. Rate calculations will be completed in future work.

Results

Firearm Mortality

Fulton County Twenty-Five-Year Homicide Perspective Analysis of National Center for Health Statistics homicide statistics for Fulton County showed a decline in overall homicide and firearm homicide over the past 10 years. Overall homicide rates averaged 31 per year per 100,000, ranging from a low in 1983 of 22 per 100,000 to a high in 1973 of 45 per 100,000. The firearm homicide rate mirrored the overall homicide rate, while the non-firearm-related homicide remained stable, averaging 10 per year.

For ages 25 and over, overall homicide declined moderately from a peak in 1973. This age group averaged 38 homicides per year per 100,000, ranging from a low of 25 in 1984 to a high of 61 per year per 100,000 population in 1973. The firearm homicide rate mirrored the overall rate. Non-firearm homicide remained stable, averaging 13 per year.

The rates for age groups 15–19 and 20–24 were strikingly different from the older age groups. Among 20- to 24-year-olds, non-firearm homicide showed minor fluctuation but remained stable. Firearm homicide accounted for nearly all of the variation in overall rates. This age group averaged 51 per year per 100,000, ranging from a low of 26 in 1983 to a high of 71 in 1972; the rate for this group has increased since 1983.

Among 15- to 19-year-olds, the average was lower—33 per year per 100,000, ranging from a low of 16 in 1983 to a high of 70 in 1994. The pattern was similar to that of the 20- to 24-year-olds, but even more pronounced. The non-firearm homicide rates

remained stable, while firearm homicide accounted entirely for the overall increase in homicide. The rate increased dramatically beginning in 1986. The highest years, 1991 and 1994, were each followed by a precipitous drop.

For ages 0–14, the rates were comparatively low, less than 10 per year per 100,000 with wide fluctuation.

Firearm-Related Deaths, Fulton County, 1989–1997

Analysis of FCME records for 1989–1997 revealed 1,994 deaths involving a firearm. Of these, 74% (1,480) were homicides, 24% (482) were suicides, 1% (19) were ruled "accidental," and 0.6% (12) involved undetermined circumstances. (The one remaining record lacked data for this variable.) The number of firearm homicides per year has remained steady, averaging 164 per year, ranging from a low of 132 in 1997 to a high of 182 in 1989 and again in 1993. Of the 1,480 victims of firearm homicides, 88% (1,298) were male and 12% (180) were female (2 additional records lacked data on the victim's gender); 85% of the victims were African-American, 12% were white. Asians and Hispanics combined accounted for 3% of the victims. Persons aged 15–24 accounted for 36% of the victims. Center of mass calculations (calculated density) place the locus of firearm homicide (all ages) in a concentrated low-income residential neighborhood (mixed residential, abandoned business use) immediately southwest of the downtown area.

Point maps of incidence by age group were created to analyze patterns of youth and young adult (0–24 years) versus adult (24+ years) homicide. The incidents show evidence of clustering in a small number of police beats, around particular public housing complexes, and along major commercial roadways.

The data were aggregated to police zone and beat; 77% of incidents matched to a zone after spatial join. Of these, 25% of firearm homicides occurred in zone 3, and 24% in zone 1. By beat, 8 beats had over 40 firearm homicides in the nine-year study period. The high-frequency beats range in size from one of the smallest (APD beat 112) to one of the largest (APD beat 405) in area.

Finally, the data were aggregated to census tracts for Fulton County. High-frequency tracts were clustered in the city proper, with the exception of the two census tracts in the southern end of the county. Nine census tracts had over 26 homicides during the nine-year study period. These high-frequency tracts were compared with the state, county, and city average on the following indicators: percent under 18 years, percent female-headed household, percent non-family household, percent high school graduate or higher (aged 25+), percent unemployed, percent male unemployed, percent below poverty level. The highest-frequency census tracts averaged 24%, 20%, and 15% higher than the state, county, and city percentage, respectively, of female-headed households. The identified tracts averaged 25%, 22%, and 13% higher than the state, county, and city percentage, respectively, for percentage of persons living below poverty level. Certain hot spot census tracts were strikingly higher on these indicators.

Firearm Morbidity

In 1997, population-based analysis of gunshot reports from area emergency departments and local law enforcement agencies identified 226 firearm homicides and 774 non-fatal firearm assaults in the five-county metro area. Sixty-five percent (65%) of the homicide victims were 34 years old or younger; 35% were between 15 and 24 years old.

Seventy-two percent (72%) of the 774 victims of firearm assault were 34 years old or younger. Forty-four percent (44%) were 24 years old or younger. In 44% of homicide and assault cases, the age, race, and sex of the suspect was recorded. In 58% of these shootings the suspect was noted to be 24 years of age or younger; 95% of the suspects were male, and 95% were African-American. There were 3.42 cases of non-fatal firearm assault for every case of firearm homicide.

Visual inspection of the point maps of the firearm assault data indicate that the events are more diffusely spread over the city and county, although this may reflect the fact that this is only one year of data; a tighter picture emerged from the nine-year homicide dataset. Clustering was identified, perhaps not surprisingly, in the hot spot areas of firearm homicide. Calculated density maps were created to determine the locus of firearm assault in the county and city. The areas of highest frequency are clustered within the city boundaries, with minimal activity in the surrounding suburban areas to the north and south. Within the city of Atlanta, the locus of firearm assault is immediately southwest of downtown, with other high-frequency areas identified surrounding several public housing units.

Firearm-Related Emergency Calls to 911

City of Atlanta 911 computer-aided dispatch data for 1997 for firearm-related call types were obtained. Call types included were 25 (shots fired); 50, 504, 5025 (person shot, person shot/ambulance sent); and 69 (person armed). In 1997 there were 10,725 firearm-related calls, an average of 894 firearm-related calls per month. Of these, 79% were "shots fired," 17% were "person shot," and 4% were "person armed." Calls from APD zones 1 and 3 together accounted for 53% of the analyzed calls.

Data were aggregated to police beat to create areal maps, which highlighted geographic concentration within zones 1 and 3. Although the beats varied considerably in size and some variation was expected, the areal maps indicated that particular beats have a much higher frequency of firearm activity than do others of similar size. There were 15 beats with under 100 calls, 20 beats with 100–200 calls, 10 beats with 200–300 calls, 6 beats with 300–400 calls, 4 beats with 400–500 calls, and one beat with over 600 firearm-related calls in 1997. This beat was also one of the highest-frequency beats for firearm assault and homicide.

A histogram of the time the calls were received in the 911 Center indicates that 32% of the calls were received between 8:00 PM and 12:00 midnight. The high-frequency time period varies between police beats and between clusters of activity. Point maps of incidence by police shift make this clear; in certain identifiable areas, the incidents occur primarily between 11:00 PM and 7:00 AM. In other identifiable areas, incidents occur primarily between 3:00 PM and 11:00 PM.

By overlaying point maps from the three datasets—firearm homicide, assault, and 911 calls—clusters of activity were easily identifiable in specific neighborhoods and streets. Using as an example APD zone 3, a cluster was identified at a public housing unit and its surrounding neighborhood in Beat 309. This beat is consistently the highest-frequency beat for firearm crime and victimization.

Discussion

GIS analysis can help public health and law enforcement agencies identify the best time

and place to concentrate their resources, as well as measure the effectiveness of interventions to reduce crime and victimization, death, and injury in our communities. In the project area, the crime and public health problem of firearm morbidity and mortality was not evenly distributed, and GIS analysis of firearm homicide, assault, and emergency calls to 911 demonstrated this clearly. The identified high-frequency areas for the events were concentrated within two police zones and eight beats within the city. Within the beats, there was further concentration on specific streets and surrounding certain public housing units. These areas scored high on poverty indices, including percent female-headed household, unemployment, and persons living below the poverty level. Further, these areas are identified high-frequency areas for drug abuse and drug market activities.

In 1997, several local agencies joined forces in a collaborative effort to reduce overall gun violence in the city, with a special focus on juvenile gun violence. The Atlanta Police Department, the Atlanta Office of the Bureau of Alcohol, Tobacco and Firearms (ATF), the Georgia State Board of Pardons and Paroles, the Fulton County Juvenile Court, the Fulton County District Attorney, Fulton County Probation, and the Emory Center for Injury Control, as well as others, participate in this effort.

The APD Guns and Violent Crime Suppression Unit and partners are carrying out targeted law enforcement activities designed to reduce the flow of illegal weapons in the city of Atlanta (particularly those to juveniles and young adults) and reduce overall criminal firearm activity and victimization. The unit has targeted enforcement initiatives in identified hot spot areas and high-incidence time periods using the GIS data analysis provided by the authors. The unit also participates in the ATF Youth Crime Gun Interdiction Initiative, cooperative investigations with the APD Gang Task Force, pawn shop investigations, and probation enforcement. The unit works cooperatively with the ATF, the Fulton County District Attorney, and the United States Attorney's Office to develop cases appropriate for state or federal prosecution.

Future Plans

These data will be used to evaluate the impact of the multi-agency intervention to reduce firearm violence described above. In future work, the authors plan to complete analyses to determine if the geographic distribution of events is regular, random, or clustered. Visual inspection indicated clustering, but further analyses are needed to confirm or refute this finding. Finally, the authors will separate the data by year for time series analysis and views, to determine if the areas of high frequency have remained stable or shifted over time.

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References

1. Rosenberg HM, Ventura SJ, Maurer JD, Heuser RL, Freedman MA. 1996. *Births and deaths: United States, 1995*. Monthly vital statistics report. Hyattsville, MD: National Center for Health Statistics. 45(3) supp 2:31.
2. Rich TF. 1995. *The use of computerized mapping in crime control and prevention programs.* NIJ Research in Action Series. Washington, DC: National Institute of Justice. July.
3. Taylor RB, Gottfredson S. 1986. Environmental design, crime and prevention: An examination of community dynamics. In: *Communities and crime*. Ed. AJ Reiss, M Tonry. Chicago: University of Chicago Press.
4. Sherman LW, Weisburd D. 1995. General deterrent effects of police patrol in crime "hot spots": A randomized controlled trial. *Justice Quarterly* 12:625–48.
5. Weisburd D, Green L. 1995. Policing drug hot spots: The Jersey City drug market analysis experiment. *Justice Quarterly* 12:711–35.
6. Atlanta Regional Commission. 1997. *Area population projections for metropolitan Atlanta*. Atlanta, GA: Atlanta Regional Commission.